IN THE UNITED STATES

PATENT AND TRADEMARK OFFICE

PATENT APPLICATION

UNIVERSAL LABORATORY PROTOTYPING INTERFACE SYSTEM

This application claims the benefit of serial number 60/225,228 filed August 15, 2000, the complete disclosure of which is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to electronic development systems. More particularly, the invention relates to a prototyping interfacing system for use with a personal computer to test and evaluate electronic circuits.

2. Brief Description of the Prior Art

It is now common to utilize personal computers in the design and testing of electronic circuits. For example, multi-purpose input-output data acquisition cards (MIO) are available from companies like National Instruments Corporation, Austin, Texas. These cards plug into an expansion slot of a personal computer and come bundled with software which enables the

computer to function as virtual test equipment. For example, the LabVIEW software from National Instruments Corporation emulates a voltmeter and an oscilloscope and can be programmed to perform some signal processing.

At present, there is no standard way to connect a DAQ to a prototype circuit for testing and evaluation. Moreover, the presently available MIO not provide or emulate waveform function generators of fully featured digital multimeters.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a fully featured electronics prototyping system.

It is also an object of the invention to provide a fully featured electronics prototyping system which operates in conjunction with a personal computer.

It is another object of the invention to provide a fully featured electronics prototyping system which has a standard interface for connecting with circuits to be tested and evaluated.

It is yet another object of the invention to provide a fully featured electronics prototyping system which includes a waveform function generator and a fully featured digital multimeter.

In accord with these objects which will be discussed in detail below, the invention includes a main circuit board which is coupled by a 68 pin SCSI-2 connector to a National Instruments DAQ card (PCI-6024E or equivalent) which resides in a PCI slot of a personal computer running National Instruments LabVIEW software which has been enhanced to include a custom communications driver. The main circuit board includes a communications module, a manual control module, a function generator, an analog I/O module, a current amplifier and frequency calibration module, and an address and status module. The main circuit board is also provided with a first edge connector for receiving a removable protection board which has a second edge connector for receiving a removable prototyping breadboard. The protection board protects the main circuit board and the DAQ from circuit faults on the prototyping breadboard. The main circuit board communicates with the DAQ via 8 digital I/O lines.

The communications module supports 8-bit write, 7-bit addressing, 1-bit parity checking, and 8-bit read. The

communications module is used primarily to set the function generator and the digital multimeter and thus a data transfer rate of approximately 2400 bps is sufficient.

The function generator module utilizes inexpensive digital to analog converters and analog switching gates to control a low cost analog function generator chip. The controls are latched, so the function generator can hold its state indefinitely. It can be controlled from the personal computer or from the manual control module as well. The function generator can generate sine, triangle and square waves from approximately 0.1 Hz to 250 kHz. The waveform choice, coarse frequency, fine frequency, amplitude, and direct current (DC) voltage offset are all programmable. In addition, it has amplitude modulation (AM) and frequency modulation (FM) inputs from the prototyping breadboard and internally via the DAQ analog outputs. The waveform output and synchronous digital output both feed back into the DAQ via analog gates. This allows for automatic calibration and dynamic auto-tuning of frequency, amplitude and DC offset.

Using analog gates and simple linear circuits, the analog I/O module routes the analog inputs and analog outputs of the DAQ to emulate a full-featured digital multimeter. In

addition, it functions as both a 2-terminal and 3-terminal I-V curve tracer capable of characterizing diodes, transistors, etc.

The function generator and analog I/O modules use a fraction of the 128 addresses available to the DAQ. According to the presently preferred embodiment, 16 output addresses and 16 input addresses are dedicated for use by the prototyping board. Using an addressing bus made available on the prototyping board, the 8-bit data written to the prototyping board can be directed to 16 separate addresses. In addition, the prototyping board read bus can accept data from 16 separate output buffers. This allows for the development of sophisticated circuits. In addition, 32 more addresses have been reserved for future use by the prototyping board.

The invention provides a complete turnkey electronics design and testing solution in a desktop module about the size of a small VCR. It has tremendous flexibility for modification and expansion. The present invention has been designed to be a complete, affordable, computer-interfaced electronics design station including a full suite of software-based test and measure instruments. It has been designed for all experience levels, including educational interests, particularly for use at the college/university level, high school/ technical college

level, industrial/commercial setting, as well as personal/hobbyist use.

The invention goes beyond the traditional breadboard "trainer" with the power and flexibilily of computer-based instrumentation.

Because the invention has both commercial and educational applications, the terms “prototyping board”, “prototyping breadboard”, and “student board” are used herein interchangeably.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a high level block diagram of the main circuit board, DAQ card, and personal computer;

FIG. 2 is a plan view illustrating the presently preferred layout of the components of the invention;

FIG. 3 is a schematic diagram illustrating details of the communications module;

FIG. 4 is a schematic diagram illustrating details of the manual control module;

FIG. 5 is a schematic diagram illustrating details of the function generator module;

FIG. 6 is a schematic diagram illustrating details of the function generator and variable DC interface module;

FIG. 7 is a schematic diagram illustrating details of the analog I/O module;

FIG. 8 is a schematic diagram illustrating details of the current amplifier and frequency calibration module;

FIG. 9 is a schematic diagram illustrating details of the circuits used in the protection board; and

FIGS. 10 and 11 are a schematic diagram illustrating details of the address and status module.

BRIEF DESCRIPTION OF THE APPENDIX

The custom communication driver of the invention is included herewith on an ISO 9660 format CDROM. As mentioned above, the communications driver is intended to be used with National Instruments LabVIEW software which is available in versions for WINDOWS, UNIX, SUN SPARC and MACINTOSH operating

systems. The filename of the driver is "ulis comm core.llb". It is a LabVIEW library file containing the main program "ulis comm core driver.vi" and 18 custom subprograms (subvis). It was written in LabVIEW 6.0 on a Windows 98 machine and can be opened with LabVIEW 6.0 or higher on any LabVIEW -compatible platform. The documentation is built into the front panels and diagrams of the various program components.

DETAILED DESCRIPTION

Turning now to FIG. 1, the invention includes a main circuit board 10 which is coupled by a 68 pin SCSI-2 connector 12 to a National Instruments DAQ (PCI-6024E or equivalent) 14 which resides in a PCI slot of a personal computer running National Instruments LabVIEW software 16 which has been modified to include a communications driver 18.

The main circuit board 10 includes a communications module 20, a manual control module 22, a function generator 24 and associated interface 25, an analog I/O module 26, a current amplifier and frequency calibration module 28, and an address and status module 30. These components are coupled to each other as shown in FIG. 1.

Referring now to FIG. 2, the main circuit board 10 is also provided with a first edge connector 32 for receiving a removable protection board 34 which has a second edge connector 36 for receiving a removable prototyping breadboard 38. The edge connectors 32, 36 are preferably EISA 98 pin edge connectors. A pair of card slides 40, 42 are located on either side of edge connector 32. The cards 34 and 38 are installed/removed by sliding them in the direction of the arrow A. Thus, the prototyping board 38 may be installed with or without the protection board 34.

As illustrated schematically in FIG. 2, the presently preferred embodiment includes a front panel 44 which is controlled by the manual control module (22 in FIG. 1), a power cord 46, and a power switch 48. The front panel 44 has a plurality of dials and switches which can be used to operate the circuits on the main circuit board and/or which can be used by the prototyping board. Details of the manual control module are illustrated in FIG. 4.

The protection board 34 protects the main circuit board and the DAQ from circuit faults on the prototyping breadboard. It includes a number of fuses 50, resistor network

chips 52 and diode network chips 54. Details of the protection board 34 are illustrated in FIG. 9.

Referring once again to FIG. 1, the main circuit board 10 communicates via the communications module 20 with the DAQ 14 via 8 digital I/O lines 56. The communications module 20 supports 8-bit write, 7-bit addressing, 1-bit parity checking, and 8-bit read. The communications module 20 is used primarily to set the function generator 24 (via the function generator interface 25) and the analog I/O module 26 (via the current amplifier and frequency calibration module 28). Thus, a data transfer rate of approximately 2400 bps is sufficient. Details of the communications module are illustrated in FIG. 3.

The function generator module 24 (and interface 25) utilizes inexpensive digital to analog converters and analog switching gates to control a low cost analog function generator chip. The controls are latched, so the function generator can hold its state indefinitely. It can be controlled from the personal computer or from the front panel (44 in FIG. 2) as well. The function generator can generate sine, triangle and square waves from 0.1 Hz to 250 kHz. The waveform choice, course frequency, fine frequency, amplitude, and direct current (DC) voltage offset are all programmable via the interface 25.

In addition, the frequency generator module 24 has amplitude modulation (AM) and frequency modulation (FM) inputs 58 from the prototyping breadboard and internally via the DAQ analog outputs 60. The waveform output and synchronous digital output 62 both feed back into the DAQ via analog gates in the analog I/O module 26. This allows for automatic calibration and dynamic auto-tuning of frequency, amplitude and DC offset. Details of the function generator module and associated interface are illustrated in FIGS. 5 and 6.

The analog I/O module 26 uses analog gates and simple linear circuits to route the analog inputs and analog outputs of the DAQ 14 to emulate a full-featured digital multimeter. In addition, it functions as both a 2-terminal and 3-terminal I-V curve tracer capable of characterizing diodes, transistors, etc. Details of the analog I/O module are illustrated in FIG. 7.

The function generator and analog I/O modules 24, 26 use a fraction of the 128 addresses available to the DAQ. According to the presently preferred embodiment, 16 output addresses and 16 input addresses are dedicated for use by the prototyping board. Using an addressing bus made available on the prototyping board, the 8-bit data written to the prototyping

board can be directed to 16 separate addresses. In addition, the prototyping board read bus can accept data from 16 separate output buffers. This allows for the development of sophisticated circuits. In addition, 32 more addresses have been reserved for future use by the prototyping module.

As mentioned above, FIGS. 3-11 illustrate the components of the invention is detail. Those skilled in the art will have a better appreciation of these Figures through reference to the following parts list.

Category	**Subgroup**	**Item**	**Description**
Internal Electronics Board			
	Digital Logic		
		74HC02	quad NOR
		74HC04	hex Inverter
		74HC08	quad AND
		74HC32	quad OR
		74HC74	dual D latch
		74HC85	4 bit comparator
		74HC123	dual one shot
		74HC138	3 to 8 decoder
		74HC139	dual 2 to 4 decoder
		74HC148	8 to 3 encoder
		74HC154	4 to 16 decoder
		74HC157	quad 2 in mux
		74HC165	parallel to serial 8 bit
		74HC175	quad D latch
		74HC273	octal D latch
		74HC280	parity generator
		74HC541	octal tri-state buffer
		74HC595	serial to

			parallel 8 bit
		74HCT541	octal tri-state buffer
	Digital Bidirectional Gating		
		74HC4053	triple 2-ch analog mux
	Analog Gating		
		74HC4051	8-ch analog mux
		74HC4053	triple 2-ch analog mux
		DG509 (Harris)	dual 4 to 1 analog mux
	Digital to Analog Converters		
		TLC7226(Tex.Inst.)	quad 8-bit DAC
		AD7523(Analog Dev.)	four quadrant 8-bit mult DAC
	Function Generators		
		XR2206 (Exar)	sin, sq, tri, function generator
	Operational Amplifiers		
		LM741	741 op amp
		LM348	quad 741 op amp
		LF411	JFET op amp
	Transistors		
		2N3904	npn 100 mA
		2N3906	pnp 100 mA
	High Stability Timing Capacitors		
		100u	tantalum
		80u	tantalum
		10u	tantalum
		1u	tantalum
		0.1u	polystyrene
		10n	polystyrene
		2.2n	polystyrene
		1n	polystyrene
	Trim Pots		

		5k	15 turn potentiometer
		10k	15 turn potentiometer
		20k	15 turn potentiometer
		50k	15 turn potentiometer
		100k	15 turn potentiometer
	Single-in-Line Bussed Resistors		
		100k	10 pin
	Connectors		
		98 pin EISA card edge	standard extended ISA
		68 pin D-type (uwscsi)	connect to E-series DAQ
		26 pin ribbon	connect to front panel
	Individual Resistors		
		1/4w metal film	5% (appx numbers)
		1/2w metal film	5% (appx numbers)
		1/4w carbon	10% (appx numbers)
	Capacitors		
		misc value ceramic	(appx numbers)
		10u	electrolytic (appx numbers)
FrontPanel Board			2" x 9" inch, double sided, .02" linewidth
	Switches		
		8 position rotary	8 position rotary w/ kbob
		3 position rotary	3 position rotary w/ knob
		momentary pushbutton	momentary pushbutton
		spst toggle	spst toggle

		4pst	student DC power switch
	Potentiometers		
		100k	single turn w/ knob
	LEDs		
		standard	multiple colors
	Connectors		
		26 pin ribbon	connect to internal board
	Individual Resistors		
		1/4w carbon	10% (appx numbers)
	Capacitors		
		misc value ceramic	ceramic (appx numbers)
		10u	electrolytic (appx numbers)
Protection Board			Estimate: 10"x3" double-sided, plated-thru,
	Fuses		.007" linewidth
		10 A slow	10 A slow
		1.5 A fast	1.5 A fast
		1/8 A fast	1/8 A fast
	Soldered PC Mount Fuse Holder Pairs		
		standard fuse holders	standard fuse holders (pair)
	Dual-in-Line Resistor		
		100 ohm	isolated 16 pin DIP
		1k	isolated 16 pin DIP
	Dual-in-Line Diodes		
		100 mA	Isolated 8 ch bussed DIP
	IC sockets		
		16 pin	standard 16 pin DIP

	Connectors		
		98 pin EISA card edge	standard extended ISA
Student Board			12" x 10" inch, double sided, .02" linewidth
	Breadboards		
		640 tie point (3M)	work area
		100 tie point (3M)	voltage rails
	Soldered Tie Points		
		1x5 PC mount (3M)	tie points to PC board traces
		2x5 PC mount (3M)	tie points to PC board traces
		3x5 PC mount (3M)	tie points to PC board traces
		1x2 LED PC mnt (3M)	tie points w/ LED slot
	LEDs		
		5V	LEDs w/ internal resistor
		12V	LEDs w/ internal resistor
	Connectors		
		Banana (Deltron)	PC mount side entry
		9-pin D-type	PC mount male, standard serial
PowerSupply			
	Transformer		
		5 tap, center tap	for +12V, +5V @ ~1.5A
	Voltage Regulators w/ Heat Sinks		
		7905	Pos 5V @ 1.5 A
		7805	Neg 5V @ 100 mA
		7912	Pos 12V @ 1.5 A
		7812	Neg 12V @ 1.5 A
	Diodes		
		1N4001	power diodes
	Capacitors		

		1000u @ 50V	input stabilizer caps
		100u A 35V	output stabilizer caps
	AC Line		
		power entry module	integrated fuse and 120/220
		standard power cord	country of destination
	Fan		
		AC is better	DC brushless are noisy

There have been described and illustrated herein methods and apparatus for prototyping electronic circuits. While particular embodiments of the invention have been described, it is not intended that the invention be limited thereto, as it is intended that the invention be as broad in scope as the art will allow and that the specification be read likewise. It will therefore be appreciated by those skilled in the art that yet other modifications could be made to the provided invention without deviating from its spirit and scope as so claimed.